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WAVE-E: The WAter Vapour European-Explorer Mission

David Jimenez-LLuva, Michael Deiml, Sara Pavesi, and the Alpbach Summer School 2016 Green Team
Students at the Alpbach Summer School 2016

In the last decade, stratosphere–troposphere coupling processes in the Upper Troposphere Lower Stratosphere (UTLS) have been increasingly recognized to severely impact surface climate and high-impact weather phenomena. Weakened stratospheric circumpolar jets have been linked to worldwide extreme temperature and high-precipitation events, while anomalously strong stratospheric jets can lead to an increase in surface winds and tropical cyclone intensity. Moreover, stratospheric water vapor has been identified as an important forcing for global decadal surface climate change. In the past years, operational weather forecast and climate models have adapted a high vertical resolution in the UTLS region in order to capture the dynamical processes occurring in this highly stratified region. However, there is an evident lack of available measurements in the UTLS region to consistently support these models and further improve process understanding. Consequently, both the IPCC fifth assessment report and the ESA-GEWEX report 'Earth Observation and Water Cycle Science Priorities' have identified an urgent need for long-term observations and improved process understanding in the UTLS region.

To close this gap, the authors propose the 'WAter Vapour European - Explorer' (WAVE-E) space mission, whose primary goal is to monitor water vapor in the UTLS at 1 km vertical, 25 km horizontal and sub-daily temporal resolution. WAVE-E consists of three quasi-identical small (∼500 kg) satellites (WAVE-E 1-3) in a constellation of Sun-Synchronous Low Earth Orbits, each carrying a limb sounding and cross-track scanning mid-infrared passive spectrometer (824 cm-1 to 829 cm-1). The core of the instruments builds a monolithic, field-widened type of Michelson interferometer without any moving parts, rendering it rigid and fault tolerant. Synergistic use of WAVE-E and MetOp-NG operational satellites is identified, such that a data fusion algorithm could provide water vapour profiles from the surface to the lower stratosphere. The mission strategy involves a pioneering launch of WAVE-E 1 followed by a joint launch of WAVE-E 2 and 3, minimizing both costs and risks as well as naturally offering a descoping option only affecting the temporal resolution of the mission. Assuming a nominal lifetime of five years for each satellite, the rough order of costs estimate amounts to ∼600M€ for the overall mission, while numerous cost reduction potentials remain open due to the early stage of instrument and mission design.

The space mission concept 'WAVE-E' was developed by a team of 15 students with the support of two tutors at the Alpbach Summer School 2016, a ten-day design challenge organised by FFG and ESA and devoted to 'Satellite Observations of the Global Water Cycle'. The concept won the 'best science case' and 'best presentation' awards.